Mathematical Models and Methodologies in Batch Process Scheduling

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Batch process scheduling is one of the most important problems to be solved in process systems engineering, since it is of upmost importance for a chemical facility to utilize the available resources and equipment units in the most favourable way. In general, the aim of scheduling is the assignment of tasks to equipment units and time intervals in consideration of a certain objective.

Most of the work published in the literature applies mixed-integer linear programming (MILP) as the mathematical model to tackle these type of problems. The two main features, that usually characterize an MILP formulation is the selection of the binary variables and the representation of the time domain. A comprehensive overview of the available models has been published by Floudas and Lin [1] and Mendez *et. al* [2]. Even though literature provides many papers on the description of different formalizations, there are no studies considering and analysing the modelling step in the optimization process. As the validity of the models is usually not proven, unexpected behaviour can arise, which may result in suboptimal or even infeasible solutions of the original problem. A recent study by Hegyháti *et. al.* [3] has examined a literature example, where the supposedly optimal solution was infeasible in practice.

Sanmarti *et. al.*[4] has developed the S-graph framework for the algorithmic scheduling of batch chemical processes with non-intermediate storage policy. Unlike the MILP formulations, this new graph-theoretic methodology ensures the validity of the model, thus, it always provides the globally optimal solution. In later publications, the framework has been extended to handle a wider range of scheduling problems by Majozi and Friedler[5], and Adonyi *et. al.*[6, 7].

In the present work the published mathematical models and methodologies are detailed and analized, focusing on their validity, flexibility and efficiency.

References

[1] Floudas C.A. and X. Lin, "Continuous-Time versus Discrete-Time Approaches for Scheduling of Chemical Processes: A Review", Computers and Chemical Engineering, 28 (11), 2109-2129 (2004).

[2] Mendez, C.A., J. Cerdá , I. E. Grossmann, I. Harjunkoski, and M. Fahl, "State-Of-The-Art Review of Optimization Methods for Short-Term Scheduling of Batch Processes," Computers & Chemical Engineering 30, 913-946 (2006).

[3] Hegyháti, M., T. Majozi, T. Holczinger, and F. Friedler, Practical infeasibility of cross-transfer in batch plants with complex recipes: S-graph vs MILP methods, Chemical Engineering Science, 64, 605-610, (2009).

[4] Sanmarti, E., T. Holczinger, L. Puigjaner, and F. Friedler, Combinatorial Framework for Effective Scheduling of Multipurpose Batch Plants, AIChE Journal, 48(11), 2557-2570 (2002).

[5] Majozi, T. and F. Friedler, Maximization of Throughput in a Multipurpose Batch Plant Under Fixed Time Horizon: S-Graph Approach, Ind. Eng. Chem. Res., 45, 6713-6720 (2006).

[6] Adonyi, R., J. Romero, L. Puigjaner, and F. Friedler, Incorporating heat integration in batch process scheduling, Applied Thermal Engineering, 23, 1743-1762 (2003).

[7] Adonyi, R., G. Biros, T. Holczinger, and F. Friedler, Effective scheduling of a large-scale paint production system, Journal of Cleaner Production, 16 (2), 225-232 (2008).